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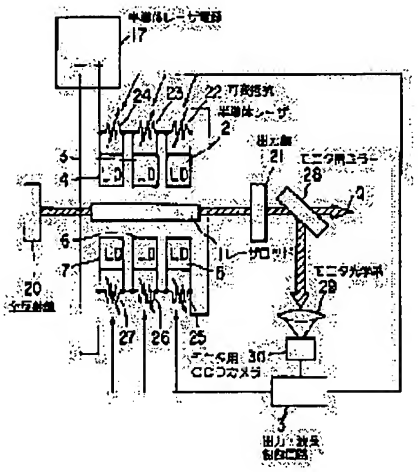
(54) **SOLID-STATE LASER**

(57)Abstract:
PROBLEM TO BE SOLVED: To stably extract laser light of symmetrical intensity distribution by uniformly adjusting the excitation distribution.
SOLUTION: Excitation distribution of a laser rod 1, when the laser rod 1 is irradiated with an excitation light generated by semiconductor lasers 2 to 7, is monitored by a CCD camera 30 for monitoring from a mirror 28 for monitoring through a monitor optical system 29. Based on the monitored excitation distribution of the laser rod 1, variable resistors 22-27 which are respectively connected in parallel with the semiconductor lasers 2 to 7 are adjusted by an output/wavelength control circuit 31 for controlling the output and wavelength of each of the semiconductor lasers 2 to 7.



LEGAL STATUS

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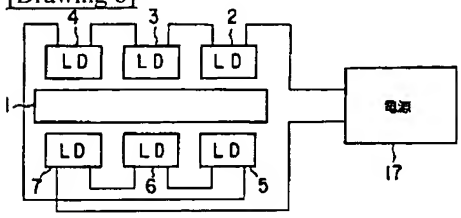
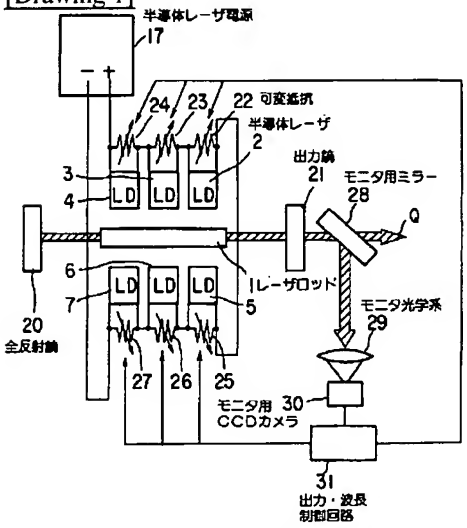
DRAWINGS

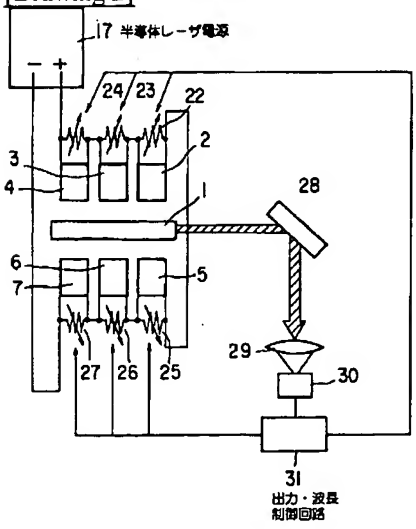
[Drawing 8]



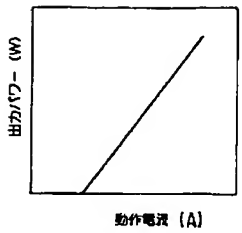
[Drawing 1]



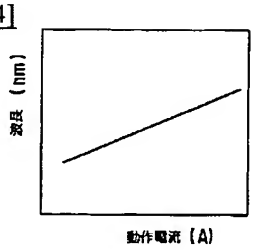
[Drawing 2]



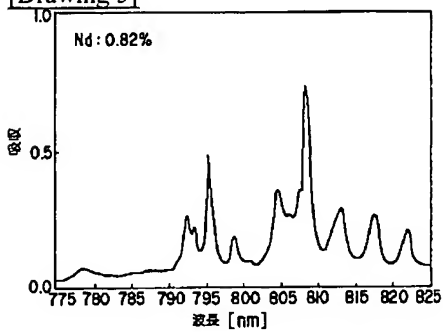
[Drawing 3]



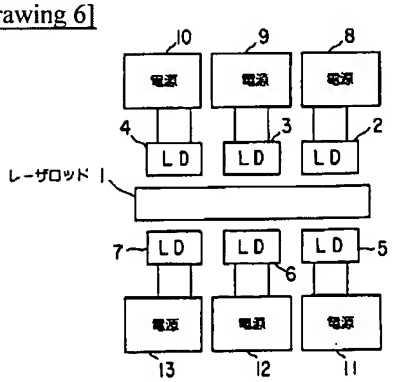
[Drawing 4]



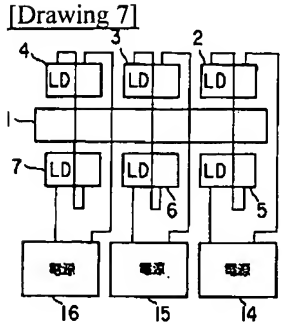
[Drawing 5]



[Drawing 6]



[Drawing 7]



[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] This invention relates to the solid-state-laser equipment which carries out optical pumping of the solid-state-laser medium, and generates a laser beam.
[0002]
[Description of the Prior Art] Generally, semiconductor laser excitation solid-state-laser equipment had the laser rod as a solid-state-laser medium, by carrying out optical pumping of this laser rod, amplified the light which generates a laser beam and was generated from the laser rod by arranging this laser rod in an optical resonator with the optical resonator, and has carried out the oscillation output.
[0003] As the excitation light source which carries out optical pumping of the laser rod in such solid-state-laser equipment, an arc lamp, a flash lamp, or semiconductor laser (LD) is known, for example, and, recently, the semiconductor laser which can output the excitation light of the predetermined wavelength absorbed by the laser rod is used more often. It is possible by using this semiconductor laser to perform optical pumping of a laser rod efficiently.
[0004] However, since the wavelength of semiconductor laser changes with the cooling temperature over the output of semiconductor laser, and semiconductor laser remarkably, the output control and temperature control to semiconductor laser are needed.
[0005] Then, about the output control of semiconductor laser, in order to control the output of semiconductor laser as indicated by JP,8-321651,A, for example, there are some which control the transistor which drives each semiconductor laser by CPU.
[0006] Moreover, about the temperature control of semiconductor laser, it controls so that the temperature of semiconductor laser becomes fixed as a cooling means using an air cooling fan, as indicated by JP,8-204263,A, for example, and there are some which attain stabilization of the output of solid-state-laser equipment.
[0007]
[Problem(s) to be Solved by the Invention] However, in order to control each semiconductor laser independently, in performing wiring from a power supply to each semiconductor laser of each and using many especially semiconductor laser, many power supplies and wiring are needed, and there is a defect that the whole equipment is enlarged.
[0008] For example, drawing 6 shows an example of the configuration of the power system to two or more semiconductor laser, makes 1 set what has been further arranged on this circumference, and is arranged two or more sets at the longitudinal direction of a laser rod while two or more semiconductor laser 2-7 is arranged in the diameter direction of the laser rod 1 at the periphery side of the laser rod 1 at a circumference top. And each direct-current constant current power supplies 8-13 are connected to every piece of these semiconductor laser 2-7, respectively. In such a power system, many direct-current constant current power supplies 8-13 and wiring of those are needed, and there is a defect that the whole equipment is enlarged.
[0009] There is a power system as shown in drawing 7 in order to lessen the number of power supplies for example. this power system -- the inside of each semiconductor laser 2-7 -- two semiconductor laser 2 and 5, 3, and 6, 4 and 7 -- it has the composition of having connected one direct-current constant current power supplies 14, 15, and 16 for every each. However, there is a defect which about [that control of each semiconductor laser 2 - 7 each cannot be performed] or three direct-current constant current power supplies 14, 15, and 16 are needed, and also shows such a configuration to drawing 6 that the whole equipment as well as equipment is enlarged.
[0010] Then, there is a power system which connected each semiconductor laser 2-7 to the direct-current constant current power supply 17 at the serial as shown in drawing 8 . With such a configuration, can attain the miniaturization of the whole equipment only by using one direct-current constant current power supply 17, but If dispersion is in the quantity of light of the laser beam outputted from each semiconductor laser 2-7, since control of each semiconductor laser 2 - 7 each cannot be performed Excitation distribution of the laser rod 1 becomes an ununiformity, it is stabilized and the laser beam of a symmetrical configuration cannot be added, but even if it is going to control the output of each semiconductor laser 2-7 in order to improve this, it has difficult composition.
[0011] And further, with the technology of JP,8-321651,A, reference is not made about the problem of the optical-pumping unevenness of a laser rod, but the transistor element which is not not much strong with heat is used.
[0012] Then, this invention can adjust excitation distribution of a laser rod to homogeneity, and aims at offering the solid-state-laser equipment which is stabilized and can add the laser beam of a symmetrical configuration.

[0013]
[Means for Solving the Problem] This invention according to claim 1 is solid-state-laser equipment equipped with two or more output-control means of semiconductor laser each to control an output at least, in solid-state-laser equipment which excites a solid-state-laser medium and generates a laser beam by irradiating excitation light outputted from two or more semiconductor laser at a solid-state-laser medium.
[0014] This invention according to claim 2 has two or more output-control means of semiconductor laser each to control an output at least, in solid-state-laser equipment according to claim 1 based on excitation distribution of a solid-state-laser medium by which the monitor was carried out with a monitor means by which an output-control means carries out the monitor of the excitation distribution of a solid-state-laser medium, and this monitor means.
[0015] In solid-state-laser equipment according to claim 1, an output-control means adjusts two or more variable resistance based on two or more variable resistance by which parallel connection was carried out to a monitor means which carries out the monitor of the excitation distribution of a solid-state-laser medium to two or more semiconductor laser at each, and excitation distribution of a solid-state-laser medium by which the monitor was carried out with a monitor means, and this invention according to claim 3 has two or more output-control circuits of semiconductor laser each which control an output at least.
[0016] In solid-state-laser equipment according to claim 1, 2, or 3, series connection of two or more semiconductor laser is carried out for this invention according to claim 4.
[0017]
[Embodiment of the Invention] Hereafter, the gestalt of 1 operation of this invention is explained with reference to a drawing.
[0018] Drawing 1 is the whole solid-state-laser equipment block diagram.
[0019] The total reflection mirror 20 and the output mirror 21 are arranged, respectively, and the laser cavity is formed in the longitudinal direction side (the direction side of an optical axis) of the laser rod 1. While two or more semiconductor laser 2-7 is arranged in the diameter direction of the laser rod 1 like the above by the periphery side of this laser rod 1 at a circumference top, two or more sets are arranged at the longitudinal direction of the laser rod 1 at it, using as 1 set what has been further arranged on this circumference.
[0020] Parallel connection of each variable resistance 22-27 for constituting the output-control means for controlling each output and wavelength is carried out to these semiconductor laser 2-7 to each semiconductor laser 2-7, respectively about these semiconductor laser 2-7.
[0021] And the semiconductor laser power supply (direct-current constant current power supply) 17 is connected to these semiconductor laser 2-7.
[0022] On the other hand, on the optical path of laser beam Q oscillated from a laser cavity, the mirror 28 for monitors for constituting the monitor means which carries out the monitor of the excitation distribution of the laser rod 1 is arranged, and CCD camera 30 for monitors is formed through the monitor optical system 29 the reflected light on the street of this mirror 28 for monitors.
[0023] This CCD camera 30 for monitors carries out the monitor of the excitation distribution of the laser rod 1, and in case each variable resistance 22-27 is set as that for adjusting each output and wavelength in the case 2-7 of this monitor, i.e., semiconductor laser, the total reflection mirror 20 and the output mirror 21 which form a laser cavity as shown in drawing 2 are removed.
[0024] An output and the wavelength control circuit 31 adjust each variable resistance 22-27 according to an individual based on the excitation distribution of the laser rod 1 by which the monitor was carried out with CCD camera 30 for monitors, respectively, and has the function which carries out feedback control of each output and wavelength about each semiconductor laser 2-7.
[0025] Next, an operation of the constituted equipment is explained like the above.
[0026] In order to adjust the output and wavelength of each semiconductor laser 2-7, in case the resistance of each variable resistance 22-27 is set up, the total reflection mirror 20 and the output mirror 21 which form a laser cavity as shown in drawing 2 are removed.
[0027] Power is supplied to this condition from the semiconductor laser power supply 17 at each semiconductor laser 2-7, excitation light is outputted from these semiconductor laser 2-7, respectively, and the laser rod 1 glares. Thereby, the laser rod 1 is excited and emits light.
[0028] It reflects by the mirror 28 for monitors, and image formation of the light which emitted light with this laser rod 1 is carried out to CCD camera 30 for monitors by the monitor optical system 29. This CCD camera 30 for monitors picturizes the light from the laser rod 1, and sends the image data of excitation distribution of the laser rod 1 to an output and the wavelength control circuit 31.
[0029] This output and wavelength control circuit 31 send out each control signal to each variable resistance 22-27, respectively so that excitation distribution of this laser rod 1 may become uniform based on the excitation distribution of the laser rod 1 by which the monitor was carried out with CCD camera 30 for monitors. Thereby, feedback control of each output and wavelength is carried out about each semiconductor laser 2-7, and excitation distribution of the laser rod 1 serves as homogeneity.
[0030] The total reflection mirror 20 and the output mirror 21 which form a laser cavity on the optical axis of the laser rod 1 are attached after each output or control of wavelength about these semiconductor laser 2-7.
[0031] Here, the property of semiconductor laser 2-7 is explained.

[0032] Drawing 3 shows the relation of the output to the semiconductor laser operating current, and semiconductor laser 2-7 has the property which an output increases to linearity mostly, if a threshold is exceeded.
[0033] Moreover, drawing 4 shows typical relation with the semiconductor laser wavelength to semiconductor laser current. If semiconductor laser package temperature rises by 10 degrees C, about 3nm of semiconductor laser wavelength will become long. That is, if the current value which flows to semiconductor laser becomes large, since semiconductor laser package temperature will also become high, it has the orientation for semiconductor laser wavelength to also become long. Therefore, control of wavelength also becomes possible by control of a current value at least.
[0034] On the other hand, the absorption coefficient to the semiconductor laser wavelength of the laser rod 1 has the property which changes remarkably with wavelength. Drawing 5 shows the absorption coefficient in a Nd:YAG crystal as a laser rod 1.

[0035] As semiconductor laser 2-7 which has the above properties, it is difficult for commercial semiconductor laser for dispersion to be in an output or wavelength and to acquire excitation distribution uniform and symmetrical with the laser rod 1 at the same same current and cooling temperature.
[0036] It is necessary to set up each variable resistance 22-27 so that excitation distribution of this laser rod 1 may become uniform from such the actual condition based on excitation distribution of the laser rod 1 like the above, and it is necessary to carry out feedback control of the output and wavelength of each semiconductor laser 2 - 7 each.
[0037] Since it is the method which controls the current value which connects variable resistance 22-27 to juxtaposition to each semiconductor laser 2-7, and flows to each semiconductor laser 2-7 when it explains with a concrete numeric value, in the case of the element of consecutive output 20W, the resistance of each semiconductor laser 2-7 is at most 0.02ohms, and the rated operating current is about 30A. What is necessary is just to set the value of these variable resistance 22-27 to 0.2 ohms, when controlling making current 3A by each variable resistance 22-27. moreover, this time -- the power consumption in each variable resistance 22-27 -- at most -- it is 1.8W and fully corresponding by commercial variable resistance is possible.
[0038] Thus, the monitor of the excitation distribution of the laser rod 1 when irradiating the excitation light outputted from each semiconductor laser 2-7 in the gestalt of up Norikazu operation at the laser rod 1 is carried out. Since the output and wavelength of each semiconductor laser 2 - 7 each are controlled based on this excitation distribution of the laser rod 1 by which the monitor was carried out Without many power supplies and wiring of those becoming unnecessary, and also enlarging the whole equipment, excitation distribution of the laser rod 1 can be adjusted to homogeneity, it is stabilized and the laser beam of a symmetrical configuration can be taken out.
[0039] In addition, this invention is not limited to the gestalt of up Norikazu operation, and may deform as follows.
[0040] For example, the means which carries out the monitor of the excitation distribution of the laser rod 1 inserts the mirror 28 for monitors between the total reflection mirrors 20 and the output mirrors 21 which constitute a laser cavity, and it may be made to carry out a monitor.
[0041]
[Effect of the Invention] As a full account was given above, according to this invention, excitation distribution of a laser rod can be adjusted to homogeneity, and the solid-state-laser equipment which is stabilized and can add a laser beam with symmetrical intensity distribution can be offered.

[Translation done.]

CLAIMS

[Claim(s)]
[Claim 1] Solid-state-laser equipment characterized by providing two or more output-control means of said semiconductor laser each to control an output at least in solid-state-laser equipment which excites said solid-state-laser medium and generates a laser beam by irradiating excitation light outputted from two or more semiconductor laser at a solid-state-laser medium.
[Claim 2] Said output-control means is solid-state-laser equipment according to claim 1 characterized by having two or more output-control means of said semiconductor laser each to control an output at least, based on excitation distribution of said solid-state-laser medium by which the monitor was carried out with a monitor means which carries out the monitor of the excitation distribution of said solid-state-laser medium, and this monitor means.
[Claim 3] Said output-control means is solid-state-laser equipment according to claim 1 characterized by to adjust two or more of said variable resistance based on two or more variable resistance by which parallel connection was carried out to a monitor means which carries out the monitor of the excitation distribution of said solid-state-laser medium to said two or more semiconductor laser at each, and excitation distribution of said solid-state-laser medium by which the monitor was carried out with said monitor means, and to have two or more output-control circuits of said semiconductor-laser each which control an output at least.
[Claim 4] Said two or more semiconductor laser is solid-state-laser equipment according to claim 1, 2, or 3 characterized by carrying out series connection.

[Translation done.]